CRATER RETENTION OBSERVATIONS OF THE CRATER FLOOR–FRACTURED ROUGH UNIT IN JEZERO CRATER.

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Introduction: A main goal of the Mars2020 Perseverance Rover mission is to provide a compelling suite of samples for eventual return to Earth [1]. A high priority goal for Mars Sample Return is calibrating Mars' crater retention isochrons that are used to date geologic surfaces and events across the planet [2]. Several factors are necessary to consider what type of rock would be most useful for this purpose: ability to retain craters across a large exposure, access to drillable outcrop, identifiable stratigraphic context, and understanding why this specific rock type preferentially retains crater morphology. Now that we've seen the surface and sampled some of the main constituent outcrops on the Crater Floor – Fractured Rough unit [3, Simon et al, this conference] (Figure 1), we can begin assessing which rocks can help us achieve this important goal to not only understand the age relationships between stratigraphic units in Jezero crater, but also improve age estimates across Mars.

***Figure 1**. Mars2020 Science Team geologic map from [2]. Tan unit is Crater Floor – Fractured Rough (Cf-Fr), green units are Crater Flour Fractured ½, and blue units represent deltaic deposits. Rover traverse in white. Blue-green dot is the rover current position as of mission sol 306.*

Retention Mechanisms: We hypothesize a few potential mechanisms that may affect rock induration and hence crater retention: interlocking minerals (i.e. igneous/metamorphic rock types), mineralogy (related to the aforementioned rock types), 'hard' cements (Si or Fe?), deep burial, and increased heating (e.g. contact metamorphism). In addition, post impact erosion, burial, or submersion may alter the rock characteristics and thus crater retention as seen on Earth [4].

Orbital observations: Many authors have noted the flat-lying Jezero crater floor preferentially retains craters [5,6] and use it to estimate the surface emplacement time anywhere from 1.4 Ga to 3.5 Ga [5,6,7,8,9]. Upon closer examination, there are several subtle morphotypes in the Cf-fr, Máaz formation [10,11], but the ones at opposite ends of a morphologic continuum are the low-lying *Pavers*, which we see in the Nataani and Roubion members [10] and the high-standing *Boulder-forming hummocks* of the Chal member [10] also in the Máaz formation. The boulders extend kilometers to the east and south, dissected by craters and forming ridges apparently on top of the pavers. The pavers are always in topographic lows though at various elevations with very low relief. This pattern occurs all across the Cf-fr with rougher areas corresponding to higher crater retention as noted by [8]. One begins to get a sense that the Chal units are more crater retaining then the smoother pavers. Inside some craters, despite aeolian fill, one can see pavers in the crater floors. Via the orbital data alone, it's difficult to discern whether the 'rough' areas are simply ejecta pavers or a separate geologic unit.

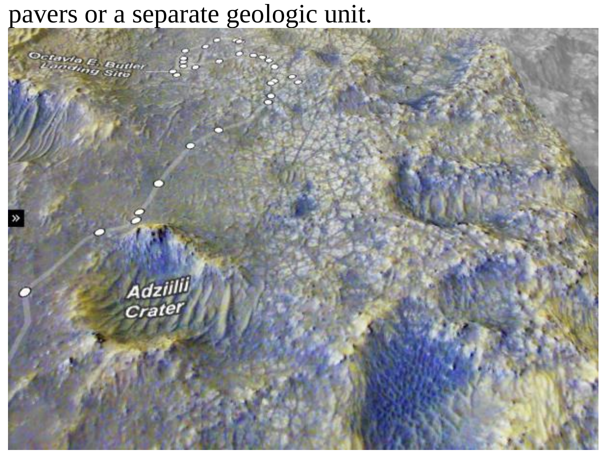

***Figure 2** HiRISE IRB image near landing site. Note the high-standing blocks on the eastern (right) side of the*

image compared to the low-lying bright polygons to the west (left). For scale, Adziilii crater is 80 m in diameter.

In Situ Observations: After landing, we were able to get a close look at the pavers (Figure 3) and bouldery unit (Figure 4). As seen in Figure 3, the pavers average centimeter-scale relief, appear easily eroded, highly fractured, with a few decimeter protuberances. No apparent layering is noted, though few paver edges are visible to assess internal layering. The bouldery unit, in contrast, as seen at a target named Chal (Figure 4) is composed of high decimeter to meter-scale boulders. Their surfaces are also smooth, but appear ventifacted with sharp, angular edges, sometimes with fluting indicating wind direction. Some surfaces can have a bumpy to pitted texture. Unlike the pavers which appear less displaced from their original deposition, the Chal boulders appear more displaced, but in this area are more or less contiguous albeit separated by aeolian sand, perhaps because they make good wind shadows for sediments to collect. Unfortunately, there's no place yet observed where we see the Chal-like material

Figure 3. *Mastcam-Z image of the paver unit. Surface roughness averages around a few centimeters with occasional protuberances at decimeter scale. This is ZCAM image . ZLF_0078_0673860129_098FDR_N0032430ZCAM08039_034085J01 from mission sol 78.*

directly connected to the underlying outcrop. While the hardened protuberances in the pavers may indicate a

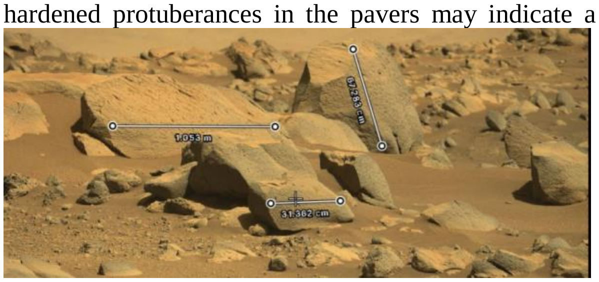

Figure 4 *High-standing boulders east of the rover landing site at a target named Chal.*

transition from easily erodible to a higher amount of induration, we have yet to see that in any exposure.

Also, we have not approached a true Chal-like boulder yet with any of our arm (PIXL/SHERLOC/WATSON) or remote chemistry (SCAM) instruments.

Observations from drilling and similar outcrops: The first drilling attempt was into the paver unit, a target called Roubion resulted in no core being collected because the rock 'disintegrated' [Simon et al., this conf.]. The next drilling attempt was farther to west, at the Rochette rock target that a) appeared stratigraphically above the paver unit, b) appeared more blocky and better indurated, and c) yielded to drill cores. While this is a very qualitative observation, the drilling data suggest that the pavers are much less indurated, or at least much more friable, then higher standing outcrops that are closer in similarity to Chal. Imaging from the accompanying abrasion patches for each drill site shows similar mineralogic assemblages with only minor variations in mineral sizes and compositions [e.g. Schmidt et al, this meeting].

Rocks for crater chronology calibration: With in situ observations tied to a closer look at orbital variances within the Cf-fr, we can draw some inferences:

1. High-standing Chal-like blocks are stronger, apparently more indurated, and less friable to low-lying pavers. No veins or obvious cements
2. Chal-like blocks are stratigraphically overlying pavers
3. There's potential evidence for a gradual transition from pavers to the boulder unit.
4. Any changes in mineralogy, to date, are subtle

The above observations lead us to hypothesize that the higher-standing boulder/hummocky Chal unit is preferentially retaining craters compared to the low-lying pavers. Sampling one of these Chal-like boulders should give us the best opportunity to date a returned sample to calibrate the crater retention age of the Cf-fr.

Summary and Future Work: Our observations show that crater retention in the Cf-fr at Jezero Crater is not the result of a distinct discontinuity between one geologic unit or separate depositional events, but a subtle facies, induration, or unobserved chemistry change in the rocks, either during or post depositional. However, we do see that these Chal-like rocks are more responsible for retaining craters in the Cf-fr and represent and excellent opportunity to calibrate the Mars crater chronology.

References: [1] Farley et al., SSR, 216, 2020, [2] Beaty, et al., https://doi.org/ 10.1111/maps.13242 [3] Stack et al., SSR, 216, 2020, [4] Kenkmann, https://doi.org/ 10.1111/ maps.13657 [5] Goudge et al, https://doi.org/ 10.1002/ 2014JE004782, [6] Shahrzad et al., https://doi.org/ 10.1029/2018GL081402, [7] Schon et al., https://doi.org/10.1016/j.pss.2012.02.003, [8] Warner et al., https://doi.org/10.1029/ 2020GL089607, [9] Marchi, Astronomical Journal, 2021 [10] Horgan et al., this conf, [11] Sun et al., this conf.